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RESEARCH **Open Access**

Total Suspended Particulate and Impaired Lung Function at Operators of Public Fuel Filling Stations in Mamuju Regency

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Abstract
The transportation sector plays a major role in air pollution in urban areas. Operators of Public Fuel Filling Stations are at risk of inhaling pollutants from motor vehicle emissions such as CO, NO, SO_2 and dust particulates. The objective of this study is to determine the relationship of Total Suspended Particulate (TSP) to the occurrence of impaired lung function at SPBU operators. This type of research is observational with a cross sectional study design with sampling technique using total sampling on the entire population, which is performing lung function examinations on 34 operators at three gas stations in Mamuju Regency. Examination of lung function used spirometry while the measurement of total dust concentration used a High Volume Air Sampler (HVAS). Data analysis was performed using the *Chi-square test*. The results showed that there was no significant relationship between TSP levels and impaired pulmonary function. Even though TSP exposure levels did not have a significant relationship with lung pulmonary function, efforts to control dust exposure were still necessary because most respondents worked in a working environment with high TSP levels. The results of this study are expected to be a reference for the implementation of health and safety programs for workers and the implementation of working environment monitoring and occupational health surveillance.

Keywords: Gas Station Operator, Impaired Lung Function, TSP

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1. INTRODUCTION

Epidemiological studies have conducted around the world and globally about seven million deaths each year are caused by air pollution (Mannucci & Franchini, 2017). The main source of air pollution comes from pollutant emissions from transportation activities ranging from motorized vehicles, trains and airplanes for both goods and passengers (Xue, et. al., 2020). Fuel oil and its disposal cause symptoms of significant health problems such as chronic cough, shortness of breath and wheezing (Uzma, et al., 2008); (Singhal, et. al., 2007). The main pollutants in motor vehicle emissions are various hydrocarbons, carbon monoxide (CO), nitrogen oxides and sulfur oxides and dust particulates including heavy metals such as lead (Pb). Organic lead and hydrocarbons are released into the air due to evaporation from the fuel system. The concentration of dust particulates can increase due to dust from the road surface, tire and brake components originating from motorized vehicle traffic (Soedomo, 2001).

The research that has been conducted shows the effects of a polluted environment on the respiratory tract. The results of research conducted in Bhopal City showed that there was a significant decrease in FEV1 (forced expiratory volume in 1 second) and FVC (Forced vital capacity) in gas station workers who were exposed for more than 5 years (Hulke, et. Al., 2012). Research in Australia also shows that vehicles have a contribution of up to 60% of air pollution, especially in summer (Victoria, 2013).

Particulate matter (PM) is usually formed in the Earth's atmosphere as a result of chemical reactions between different pollutants (Manisalidis, et. al., 2020). The concentration of dust particulates in the air can affect health if inhaled by humans. The inhaled dust particulate will be deposited into the alveoli, causing an inflammatory reaction which results in limited lung growth (Fordiastiko, et. al., 2002). One of the negative impacts arising from particulate dust exposure is a decrease in lung function in humans (Lagorio, 2006). According to WHO, 91% of the world's population live in places that do not meet air quality guideline levels. Ambient air pollution in cities and rural areas is estimated to cause 4.2 million premature deaths per year in 2016. These deaths are due to exposure to small particles 2.5 microns in diameter (PM 2.5) that cause cardiovascular and respiratory diseases and cancer (WHO, 2018). PM 2.5 recently estimated to have accounted for 3.2 million premature deaths worldwide in 2010, mostly due to cardiovascular disease and 223,000 deaths from lung cancer (Pershagen, 2012). In India in 2015, 1,800 premature deaths were recorded due to ambient PM 2.5 and ozone from transportation exhaust emissions (Susan Anenberg, et. al., 2019).

The CO gas concentration has a high enough concentration of other harmful gases. It is because 80 percent of the total vehicles in Indonesia are two-wheeled vehicles that use premium and pertamax fuels. Burning this fuel can produce CO gas. CO gas that is sucked into the lungs of humans can enter the bloodstream so that it can block the entry of oxygen and form carboxyhemoglobin which can inhibit the function of hemoglobin in the blood to carry oxygen from the lungs to the rest of the body (Wardhana, 2004).

The WHO report shows that of the total 56 million deaths in 2012, 38 million or 68.5% were caused by non-communicable diseases. The four main causes of death from PTM in the world are cardiovascular disease, cancer, respiratory disease and diabetes. Respiratory diseases including asthma and Chronic Obstructive Pulmonary Disease (COPD) rank the third leading cause of death in the world (4 million or 10.7% of total deaths due to PTM) (WHO, 2014).

COPD is a disease that is of great concern to the government in Indonesia. Riskesdas 2013 data shows that the prevalence of COPD in the age group ≥30 years from the results of the interview based on symptoms was 3.7%. The prevalence of COPD in West Sulawesi was 6.7% which was the third highest after East Nusa Tenggara (10%) and Central Sulawesi (8%), and the actual COPD patients were suspected to be higher than the results obtained because patient detection was only through questionnaire based interviews. Symptoms/complaints without examination using spirometry, while COPD sufferers only experience complaints when lung function has decreased a lot so that the actual prevalence data is likely to be greater (Kemenkes, R. I., 2013). The long-term effects are chronic, last for years and can even cause death, while the toxicity of some air pollutants can also cause various types of long-term cancer (Nakano & Otsuki, 2013). Long and short-term exposure to suspended air toxins have different toxicological impacts on humans including respiratory and cardiovascular diseases, eye irritation, skin diseases and long-term chronic diseases such as cancer (Ghorani-Azam, et. al., 2016).

West Sulawesi Province as a province which is still in the development stage is actively promoting development in various sectors. It of course can have an impact on the environment. The number of vehicles operating in West Sulawesi Province based on Samsatin Mamuju data is around 62,317 units consisting of 3,401 two-wheeled vehicles while 58,916 four-wheeled vehicles. The growth of vehicles in West Sulawesi reached 3000 percent compared to the data on the number of vehicles in West Sulawesi before becoming a new province. The large number of vehicles operating in West Sulawesi shows that the level of mobility is very high which directly has the potential to contribute to air pollution. Mamuju Regency as the provincial capital is one of the areas with significant vehicle growth.

A gas station operator is someone who is assigned to fill gas for motorized vehicles. Gas station operators are at risk of constant exposure to organic and inorganic substances in gasoline. Their average daily exposure exceeded about 10 hours/day. Gas station operators are at risk of breathing air originating from motor vehicle emissions such as SO_2, CO, NO, and dust. Basically, the value of a person's Forced Vital Capacity or *Kapasitas Vital Paksa* (KVP) is not only influenced by pollutants, but it is also influenced by individual characteristics and behavior (Sirait, 2010). The results of the study of 59 gas station employees show that there were 64% who had decreased KVP (retristive lung disease), 61% in the mild category and 3.4% in moderate restrictions (Soeroso, et. al., 2019). Workers at petroleum refineries have lung function which is severely impaired by the pattern of lung function which provides evidence supporting obstructive pulmonary disease (Meo et al., 2015).

The results of the preliminary survey on the working environment conditions of gas station operators in Mamuju Regency show that the working environment conditions of the gas station operators have a very high risk of occupational diseases. The magnitude of the risk of workers being exposed to fuel oil emissions from motorized vehicles queuing at gasoline filling machines is increasing because there are still workers who do not use personal protective equipment (PPE) while working. Furthermore, based on interviews with workers, information was obtained about complaints of illnesses commonly suffered by most workers, which are coughing and shortness of breath, but they rarely went to the primary health center or hospital because they thought these diseases were common and a consequence of work.

Based on this information, it is suspected that the iceberg phenomenon has occurred, which is the number of unregistered sufferers is much greater than those recorded because sufferers who experience coughs and shortness of breath do not go to the health center because they think their illness is normal and not serious. Moreove, it has never been conducted similar research in Mamuju Regency so that researchers consider the need for an examination of the capacity of lung function to detect early impaired lung function in workers as well as measurement of TSP concentration. The objective of this study is to determine the relationship between TSP and the occurrence of impaired lung function in gas station operators in Mamuju Regency in 2019.

2. RESEARCH METHOD

This type of research is an observational study with a cross-sectional design. In the study, TSP concentration was measured in the workplace air using a High Volume Air Sampler (HVAS) tool, CO gas concentration was measured using an Air Quality Monitor, while lung function examination was the result of a pulmonary specialist's diagnosis using the results of a spirometric examination, namely comparing FEV1 (Forced Expiratory Volume). in one second) with FVC (Forced Vital Capacity). In addition, interviews were conducted to obtain information related to individual factors, namely gender, age, years of service, length of work, history of disease and severity of smoking and exercise habits. Information on the behavior of gas station operators, namely the use of PPE, was obtained through observation, while the assessment of the nutritional status of the respondents was obtained by using a weight scale and height measurement. Impaired lung function were categorized into two types, which are no disturbance and impaired lung function. TSP and CO concentrations were categorized into two types which are fulfilling the requirements and not fulfilling the requirements by referring to the NAV value regulated in Government Regulation No. 41, 1999. Data analysis was administered using chi square analysis.

This research was conducted at three gas stations that are H. Laumma gas station, Kali Mamuju gas station and Kalukku gas station in Mamuju Regency. This research was conducted in May - July 2019 with a recommendation for ethical approval from the Ethical Research Commission for Health Polytechnic of the Ministry of Health Makassar No: 134/KEPK-PTKMKS/II/2019. The study population was all 34 operators in three gas station in Mamuju Regency. The sampling technique was conducted by the total sampling method where the sample was the entire population of 34 people. Determination of the TSP and CO gas measurement points based on the SNI-19-7119.6, (2005) reference. The measurement point is made at a point close to the source of exposure. Measurement of CO gas concentration was conductedone time during the day based on the Ministry of Environment Number 12 (2010) which there is a time span during the day between 10.00-14.00 WITA while TSP measurement using HVAS was performed for 24 hours (Kementerian Lingkungan Hidup, 2010).

3. RESULTS AND DISCUSSION

Table 1. Examination Results of Total Suspended Particulate (TSP) and Carbon monoxide (CO) at gas station in Mamuju District, 2019

Gas Station	TSP Content ($\mu g/Nm^3$)	Information	CO Content ($\mu g/Nm^3$)	Note
H. Laumma Simboro	266,98	Not eligible	13.156,59	Not eligible

Kali Mamuju	239,84	Not eligible	10.595,13	Not eligible
Kalukku	207,80	Eligible	11.448,95	Not eligible

Table 1 shows the results of the air quality inspection using TSP parameters at the H. Laumma Simboro gas station and Kali Mamuju gas stations that did not meet the requirements, while Kalukku gas stations did not meet the requirements. The measurement of CO levels at 3 gas stations in Mamuju District shows that the CO levels at all gas stations do not meet the requirements. The results of this assessment were obtained by comparing the measurement results with the national ambient air quality standards stipulated in Government Regulation No. 41 (1999).

Table 2. Examination Results of Total Suspended Particulate (TSP) and Carbon monoxide (CO) in the working environment of gas station Operators in Mamuju Regency, 2019

Variable	N	%
TSP Content Condition		
Eligible	7	20,6
Not eligible	27	79,4
CO Content Condition		
Eligible	0	0
Not eligible	34	100

Table 2 shows that there are 27 respondents (79.4%) who have a working environment with TSP levels that do not meet the requirements and who meet the requirements of 7 respondents (20.6%) while the results of the CO examination show that all respondents are 34 (100%) being in a working environment with levels of CO that do not meet the requirements when compared with the national ambient air quality standards regulated in Government Regulation No.41 (1999).

Table 3. Distribution of Respondents according to Impaired Lung function at gas station Operators at Mamuju Regency, 2019

Category	N	%
Normal	20	58,8
Restructive	7	20,6
Obstructive	5	14,7
Combination	2	5,9
Total	34	100

Table 3 shows the results of lung function examinations at gas station operators showing a decrease in lung function in 14 respondents (41.2%) with restructivelung function who were 7 respondents (20.6%), obstructive 5 respondents (14.7%) and a combination of 2 respondents (5.9%) while gas station operators who have normal lung function were 20 respondents (58.8%).

Table 4. Analysis of Relationship between TSP and CO levels on Impaired Lung Function at Gas Station Operators in Mamuju District, 2019

Variable	Lung Cancer		Number	OR (95% CI)	P Value
	There is impairment	There is no impairment			

	N	%	N	%	N	%		
TSP Content								
TMS	12	44,4	15	55,6	27	79	2 (0,32- 12,18)	0.67
MS	2	28,6	5	71,4	7	21		
CO Content								
>12.051 µg/Nm^3	7	41,2	10	58,8	17	50	1 (0,25-3,92)	1.00
≤ 12.051µg/Nm^3	7	41,2	10	58,8	17	50		

Table 4 shows the proportion of respondents with a working environment with TSP levels who did not meet the requirements and experienced impaired lung function as many as 12 respondents (44.4%) while respondents with a working environment with TSP levels that met the requirements and experienced impaired lung function were 2 respondents (28,6%). Whereas the proportion of respondents with a working environment with levels of CO>12,051 µg/Nm^3 and experiencing impaired lung function were 7 respondents (41.2%) while respondents with a working environment with levels of CO ≤ 12,051µg/Nm^3 and experiencing impaired lung function were who were 7 respondents (41, 2%). The results of the analysis between TSP levels and CO levels with impaired lung function showed no significant relationship between TSP and CO levels with impaired lung function.

Table 5. Analysis of the Relationship of Individual Factors (Gender, Age, Nutritional Status and Working Period) to Impaired Lung Function at gas station Operators in Mamuju District, 2019

Variable	**Lung Function**				**Number**		**OR (95% CI)**	**P Value**
	There is impairment		**There is no impairment**					
	N	**%**	**N**	**%**	**N**	**%**		
Gender								
Male	10	37,0	17	63.0	27	79.4	0,44 (0,08-2,38)	0,410
Female	4	57,1	3	42.9	7	20.6		
Age								
≥ 30 years	3	42,9	4	57.1	7	20,6	1,09 (0,20-5.86)	1,000
< 30 years	11	40,7	16	59.3	27	79,4		
Nutrition Status								
Not normal	11	50,0	11	50.0	22	64,7	3,00 (0,64-14,15)	0,275
Normal	3	25,0	9	75.0	12	35,3		
Working period								
≥ 5 years	3	27,3	8	72.7	11	32,4	0,41 (0,09-1,94)	0,295
< 5 years	11	47,8	12	52.2	23	67,6		

**MS: Eligible, TMS: Not Eligible*

Table 5 shows the results of the analysis between individual factors (gender, age, nutritional status and working period) and impaired lung function. It shows that there is no significant relationship between gender, age, nutritional status and working period with impaired lung function.

Table 6. Analysis of the Relationship of Behavioral Factors (Use of PPE, Sports Habits and Smoking Habits) to Impaired Lung Function at Gas Station Operators in Mamuju Regency, 2019

Variable	Lung Function				Number		OR (95% CI)	P Value
	There is impairment		There is no impairment					
	N	%	N	%	N	%		
APD Use								
No	7	53,8	6	46,2	13	38.2	2,33 (0,56-9,63)	0,296
Yes	7	33,3	14	66,7	21	61.8		
Smoking Habit								
Yes	8	38,1	13	61.9	21	61,8	0,72 (0,17-2.92)	0,916
Not	6	46,2	7	53.8	13	38,2		
Exercise Habit								
No	9	47,4	10	52,6	19	55,9	1,80 (0,44-7,31)	0,495
Yes	5	33,3	10	66,7	15	44,1		

Table 6 shows the results of the analysis between the Behavioral Factors, which were the use of PPE, exercise habits and smoking habits with impaired lung function, showing no significant relationship.

The results of air quality inspection using the TSP parameter at the Kalukku gas station show that the TSP levels at the H. Laumma Simboro gas station and Kali Mamuju gas station do not meet the requirements, while the Kalukku gas station meets the requirements. H. Laumma gas station has the highest TSP level because it is located on a protocol road and has a large gas station area of 5,000 m^2 and serves more customers compared to the other 2 gas stations, which are 200 cars and 300 motorbikes per day on average.

The source of high TSP pollution comes from the combustion of fossil fuels from motorized vehicles and motorized vehicle traffic from the asphalt surface, tire and brake components. TSP contains a variety of good metal, organic and other components that can adversely affect both animals and plants in the environment (Fitria, 2009). Meanwhile, the source of CO pollution comes from heavy traffic as a result of burning fossil fuels from motorized vehicles. Areas with high population levels with dense traffic will have higher levels of CO than rural areas (Fernando, et. al., 2013). The existence of an insignificant relationship between TSP levels and impaired lung function in this study was probably due to the influence of most respondents being in an environment with TSP levels that did not meet the requirements. Moreover, it was found in several cases that the majority of respondents who worked in a qualified environment also had other risky habits that could lead to impaired lung function, which are smoking and not using PPE while working. Furthermore, the yield factor is still influenced by the chance factor because the sample is small.

The results of lung function examinations at gas station operators showed that there was a decrease in lung function with the most restrictive type at gas station operators, which were 7 respondents (20.6%). The results of the research analysis showed that there was no significant relationship between TSP Levels and Impaired Lung Function. The results of this study are not in line with the previous studies that found an association between increased PM concentrations and impaired lung function. A prospective cohort study by the American Cancer Society of 1.2 million American

adults for 26 years (1982-2008) found that lung cancer mortality increased by 15-27% if airborne PM concentrations were increased by 10 μg/m³ (Turner et al., 2011). The same result is shown by research on carving stone craft industry workers in Sidrap Regency, which shows that workers who work in rooms that have a concentration of PM past NAV are 4.17 times more likely to suffer from impaired lung function compared to workers who work in room conditions with PM concentrations that meet the NAB (Ahmad & Wulandari, 2018). Similar to the results of research on Overhaul Power Plant workers, it was found that only dust exposure was shown to have a significant relationship with impaired lung function ($p=0.006<\alpha=0.05$) with the greatest prevalence of workers experiencing combination impairedlung function (Ardam, 2015). Particulate exposure for 5-6 years can cause impaired lung function (Borm, et. al., 2002). Reduction of exposure to steam, gas, dust and asp in the workplace will be an effective method for reducing COPD disease (Fishwick et al., 2015).

The results of the study are also not in line with the theory that the concentration of particulate matter in dust when inhaled by humans can harm health. Dust particulates when inhaled will be deposited into the alveoli which can cause an inflammatory reaction which results in a limited expansion of the lungs (Fordiastioko, 2002). Decreased lung function in humans is one of the impacts caused by exposure to dust particulates (Lagorio, et. al., 2006). Epidemiological, biomedical and clinical studies show PM in air pollution is strongly associated with an increase in cardiovascular disease (Du, et. al., 2016). PM exposure is shown to have not only a few adverse but also significant effects on cardiovascular, respiratory and cerebrovascular disease (Anderson, et. al., 2012). The long-term effects of PM exposure range from simple ones such as irritation of the nose, eyes, throat, skin, cough and difficulty breathing to more serious effects such as bronchitis, asthma, pneumonia and lung disease. Short-term PM exposure can also cause dizziness, nausea and headaches (Mohammed & Saleh, 2020).

The results of the analysis of the research between individual factors, which is age, show that there is no significant relationship between age and impaired lung function. The results of this study are not in accordance with the theory that usually at the age of 30 years, there is a decrease in lung function, where the value of lung function (KVP and VEP1) decreased on average by about 20 ml per one year increase in individual age (Janssens, et. al., 1999). The development of the human respiratory system, especially alveolar tissue, up to 80% of its development stops in late adolescence, which is 18 years in women and 20 years in men (Fortoul, et. al., 2011); (Gauderman, et. al., 2004). It is possibly because most of the respondents who were 79.4% were <30 years old and only 20.6% were aged ≥30 years. Moreover, there were several cases where respondents aged <30 years had other risky habits that could trigger disturbances of lung function, which is smoking.

The results showed that there was no relationship between working period and impaired lung function in workers. The results of this study are not in line with the theory that there are significant toxic effects of solvents and air pollutants on workers who are exposed to it for longer (Uzma, et. al., 2008). It is also inconsistent with research conducted in the Bhopal City showing that there was a significant reduction in FEV1 (forced expiratory volume in 1 second) and FVC (forced vital capacity) in gas station workers who were exposed for more than 5 years (Hulke, et al., 2012). Likewise, there is a relationship between the length of exposure to motorized vehicle dust and the vital capacity of the lungs in gas station operators in Kupang City with p=0.002 (Ganggut, et. al., 2018). As well as other research that working period has a significant relationship with lung vital capacity (Setiawan & Hariyono, 2011); (Simanjuntak, et. al., 2015). There is an insignificant relationship between working period and impaired lung

function in this study because the average working period of the respondents is less than 5 years. Furthermore, it was found in several cases that most of the respondents who worked for less than 5 years had other risky habits that could lead to impaired lung function, which were smoking and not using PPE while working.

The results showed that there was no correlation between smoking behavior and impaired lung function among gas station operators. It is because the smoking status in this study was only based on smoking and non-smoking status, while passive smoking status was not included so that it could affect the results of the study. It is not in line with research explaining that cigarette smoke can affect human lung function (Cui, et. al., 2010).

The results showed that the use of PPE has no relationship with impaired lung function, which is not in accordance with the theory, which explains that the use of personal protective equipment in the form of masks is related to the concentration of particulates due to contamination in the lung organs which can cause impaired lung function, the use of PPE masks can prevent the deposits of pollutants particulate in the lung organs which can result in decreased lung function (Suma'mur, 2009). The use of PPE in gas station operators is still low due to inconvenience, being disrupted when serving consumers, knowledge and availability of PPE in the workplace (Pamelia & Airlangga, 2019). Moreover, the selection of a good PPE includes the type and nature of the hazard, the duration of the exposure and the limit of the protective equipment's capabilities (Moeljosoedarmo S, 2008).

There is an insignificant relationship between the use of PPE and impaired lung function in this study because the status of using PPE in this study is only based on using and not using PPE, while the type of PPE that meets the requirements and does not meet the requirements for use in filtering dust has not been included in the criteria for PPE use. Furthermore, it was found in several cases that the majority of respondents who worked for less than 5 years had other risky habits that could lead to impaired lung function which is smoking habit.

4. CONCLUSION

There was no significant relationship between TSP, CO levels, individual and behavioral factors (gender, age, and working period, use of PPE, exercise habits and smoking habits) with impaired lung function. Although the level of TSP exposure does not have a significant relationship with impaired lung function, it is still necessary to make efforts to control dust exposure because most of the respondents work in a working environment with TSP levels that do not meet the requirements and the high incidence of impaired lung function among respondents.

The results of the analysis show that an insignificant relationship may be influenced by the chance factor due to the small number of samples. In this study, total sampling has been used, but due to the limited population size, the sample is also small. Another factor that can affect the insignificant results is the presence of confounding factors that can affect the occurrence of impaired lung function in addition to the main risk factor, which is TSP level. It is recommended for further researchers to conduct research with a larger research scope so that a large sample is obtained and to perform multivariate analysis to validate the relationship between one main variable and the dependent variable by controlling several confounding variables.

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